Design and optimization of Infrared Heating Systems

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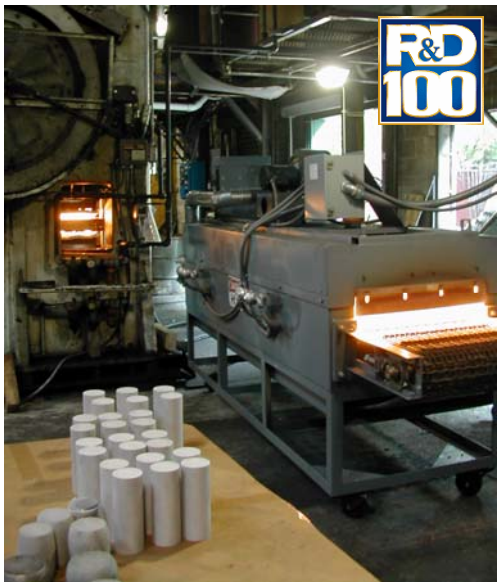
Award The original project, *Advanced Heating Furnace for High-Performance Aluminum Forgings*, was the recipient of the 2004 R&D100 Award.



Description The Advanced Heating System uses an optimized combination of radiant and convection heating for processing materials; where the radiant part of heating is delivered through the short-wavelength (0.78~2.0 μm) infrared radiations emitted by heating an array of tungsten-halogen filaments to very high temperatures (in excess of 2200°C). The unique combination when used to heat aluminum alloy billets prior to forging, reduces heating time and energy consumption, prevents grain growth and produces high-performance forgings with significantly improved tensile and fatigue properties, compared to those heated by conventional techniques.

Benefits Advanced Heating System (AHS) offers a low-cost, energy-efficient, and environmentally friendly heating methodology for process heating with significant enhancement in material properties. The AHS offers following advantages or improvements over conventional gas-fired heating methods:

- An order of magnitude higher heat flux that results in an order of magnitude faster heating rates for aluminum billets.
- Optimized radiant and convective heating results in rapid and efficient heating, increasing the production rate by a factor of 4.
- Optimized radiant and convective heating results in highly efficient heating, using only one-third of the energy used by conventional gas-fired methods to heat aluminum.
- The conversion of electrical to radiant energy and its optimization with convection heating makes the AHS 30% energy efficient while gas-fired heating is only 10% efficient.
- The AHS reduces the heating time and thereby results in an order of magnitude finer grain size than conventional gas-fired heating.
- Extensive grain refinement results in the enhancement of fatigue properties. Forged aluminum components survive two times longer than components produced using conventional gas-fired heating.

Current Status of Technology The technology was developed as a part of DOE's Industrial Technologies Program, Supporting Industries sponsored initiatives, "Enhancement of Aluminum

Alloy Forgings through Rapid Billet Preheating". The system was developed at Oak Ridge National Laboratory in collaboration with The Queen City Forging, Northeastern University, Infrared Heating Technologies and Forging Industry Association.

Field testing of this system in a full-scale production setup has demonstrated cost savings of 40 to 50% through reduced energy consumption, increased throughput, and improved consistency in the process and the product. High-performance aluminum forged components are lightweight and can serve as a less costly substitute for titanium and other expensive components in automotive and aerospace applications.

Proposed Activities New potential applications in other thermal processes, including joining and heat treatment of AHS will be investigated. The AHS will be customized to process additional materials such as steel, titanium and nickel-based alloys. This project will help industries customize the IR process heating for the specific needs used in a plant, select the most energy saving equipment, assist them in process optimization that result in improved productivity, reduction in waste and increase in energy efficiency.

The primary objective of the project is to provide plant procedures for the Infrared Heating Technology. The availability of the plant procedures and process recipes will enable a wide dissemination of technology in the US industry. These procedures will consists in (a) property measurement procedures, (b) computational procedures used for process analysis, (c) plant procedures for testing new equipment, (d) plant procedures for the application of technology to new materials, (e) procedures for process optimization for energy savings.

This technology will integrate all contain the following tasks:

1. Property measurement requirements.
2. Process analysis (data acquisition and computational analysis).
3. Formulate process recipes and plant procedures.
4. Process optimization.